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Effect of Island Overlap on ELM Suppression by Resonant Magnetic Perturbations in DIII-D[1]

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Recent DIII-D experiments show that the degree of magnetic island overlap in the plasma edge is a good predictor for suppression of edge-localized modes (ELMs), consistent with theoretical expectations. For fixed resonant magnetic perturbation (RMP) strength, ELM suppression is obtained over a finite window in the edge safety factor (q_{95}) indicating a resonant effect. In H-mode plasmas, ELM suppression is obtained over an increasing range of q_{95} by either increasing the RMP strength that produces the islands, or by adding $n = 1$ perturbations to "fill in" islands across the edge plasma. Large Type-I ELMs are completely suppressed by applying $n = 3$ RMPs in the presence of $n = 1$ error-field correction and small $n = 2$ and 3 field-error components in plasmas with electron pedestal collisionality of $\sim$0.1 and shape similar to ITER. In these experiments, the region of island overlap is changed by varying either: 1) the strength of the applied $n = 3$ RMP, 2) the edge q-profile, 3) the combination of $n = 3$ and $n = 1$ perturbations, or 4) the up-down parity of the applied $n = 3$ RMP. Each case agrees with theoretical expectations that the island overlap region width (vacuum fields) needs to be at least several times the width of the pedestal to completely eliminate ELMs. Theory predicts that the plasma response in rotating plasmas reduces the RMP amplitude from the vacuum level (RMP screening). Experiments to validate this theory have examined the detailed dependence of ELM suppression on the width of the island overlap region for two different values of edge toroidal rotation. Experimental validation of theoretical models for ELM suppression represents an important scientific advance that will provide the foundation for designing ELM control systems in future devices.

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[2]for the DIII-D Team